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Evaluation of dehydrated *marolo* (*Annona crassiflora*) flour and carpels by freeze-drying and convective hot-air drying

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ABSTRACT

Marolo (*Annona crassiflora*), an exotic fruit from the Brazilian savanna, has been used for many culinary preparations such as jelly and jam. In this study we have compared physicochemical properties, color analysis, dietary fiber and triacylglycerol analysis of *marolo* flour and carpels dehydrated by freeze-drying and convective hot-air drying. The experiments were analyzed by Tukey's test ($p<0.05$). There was a significant difference between fresh and dehydrated *marolo* as shown by the analysis of moisture, Aw, and the centesimal composition (except for the ashes).The dehydrated products showed to be sources of alimentary fiber and derivatives from oleic and palmitic acids and can be used during periods between harvests of *marolo* fruits.

1. Introduction

The Brazilian savanna is the second largest biome in South America just second to the Amazon rainforest (Proença, Oliveira, & Silva, 2000). *Marolo* (*Annona crassiflora*), also known as *Araticum*, is an exotic fruit found in the Brazilian savanna. This fruit weighs from 0.5 to 4.5 kg, and contains from 90 to 190 carpels with one seed each (Ribeiro & Pascal, 2005). Fig. 1 shows the *marolo* (*A. crassiflora*) tree (A), tree and fruit (B), fruit (C), flower (D) and cut fruit (E).

Marolo presents sensory appeal such as color, scent and flavor besides many nutritional qualities including high levels of B complex vitamins, such as thiamine (0.04 mg/100 g) and riboflavin (0.07 mg/100 g), as well as ascorbic acid (21 mg/100 g) and carotenoids (5.9 ug/g) (Agostini, Cecchi, & Godoy, 1996). In spite of these characteristics, only the native people consume *marolo* fresh in the ripe stage or frozen to prepare mainly juices, ice-creams, jellies, and jams. This limitation is reinforced by the lack of data on the quality of dehydrated products from *marolo*, as food ingredients.

Many dehydration processes are used, but freeze-drying and convective hot-air drying are the most appropriate for maintaining the biological quality of products. Freeze-drying is used and restricted primarily to industries because it requires qualified personnel and higher investment costs. In contrast, convective hot-air drying demands small investments for crop producers and small industries. This type of drying results in products that may last up to 1 year (Ratti, 2001).

The objective of this study was to evaluate the physicochemical changes for obtaining fresh and dehydrated *marolo* by freeze-drying and convective hot-air drying processes.

2. Materials and methods

2.1. Materials

Mature *marolo* fruits were harvested in 2009 in the savanna ecoregion at a farm in Machado in Minas Gerais, Brazil. The carpels of mature fruits were processed by separating the pulp from the rind and the seeds. This procedure was performed in the Laboratory of Food and Technology at Alfenas Federal University, and in the Nutritional and *In Vivo* Toxicological Analysis Laboratory, MG-Brazil.

2.2. Dehydration processes

Fresh *marolo* was submitted to a blanching process (70 °C for 5 min in hot water bath) and dehydrated by freeze-drying (F) and convective hot-air drying methods (A). Carpel and pulp dehydration with freeze-drying resulted in freeze-dried carpels of *marolo* (FCM) and freeze-dried flour from *marolo* (FFM), respectively. Carpel and pulp dehydration by convective hot-air drying resulted in convective hot-

Abbreviations: Aw, activity water; TAG, triacylglycerol; WAI, water absorption index; WSI, water solubility index; FCM, freeze-dried carpels of marolo; FFM, freeze-dried flour from marolo; ACM, convective hot-air dried carpels of marolo; AFM, convective hot-air dried flour from *marolo*.

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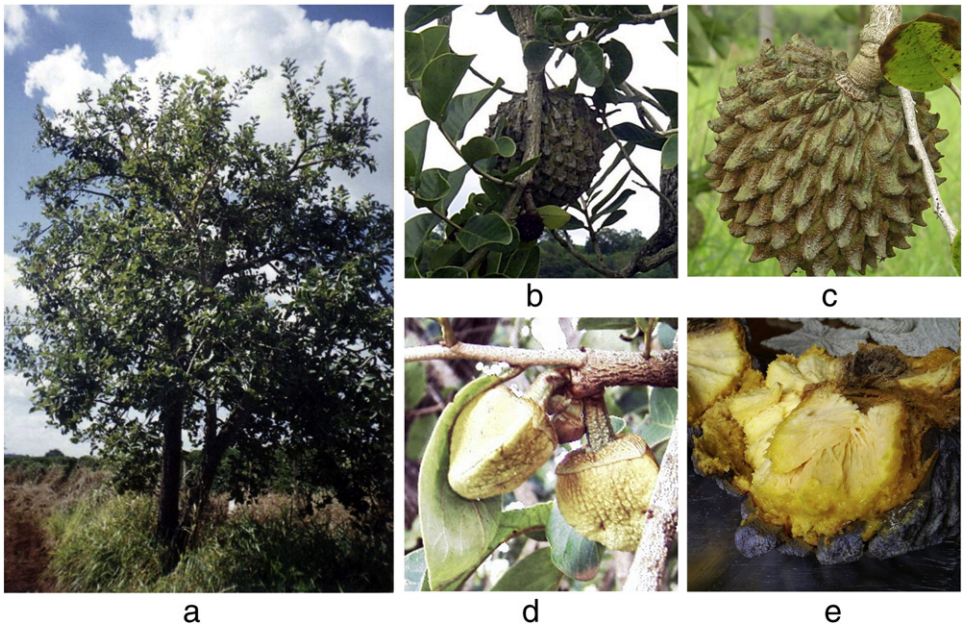

Fig. 1. A *marolo* (*Annona crassiflora*) tree (a), tree and fruit (b), fruit (c), flower (d) and cut fruit (e).

air dried carpels of *marolo* (ACM) and convective hot-air dried flour from *marolo* (AFM). After dehydration, *marolo* was ground in a blender and sifted for the uniformization of the flour granules.

For the freeze-drying (F) method, a LIOTOP-L101 drier (Brazil, São Carlos, Liobras) was used. The temperature and pressure in the closed drying chamber were −51 °C and 250 Pa, respectively. Convective hot-air drying (A) was conducted with a 400 ND drier with air circulation (Brazil, Vargem Grande Paulista, Nova Ética). The air temperature was held at 50 °C for 20 h, followed by 70 °C for 11 h until the moisture dropped below 10 g/100 g.

2.3. Physicochemical characterization of the fresh pulp and dehydrated products

The moisture content was determined with AOAC method No. 934.06 (1997). The water activity (Aw) was measured at 25 °C using an electric hygrometer Aqualab Lite (Decagon®).The ash content of the pulp was estimated by incineration in a muffle furnace at 550 °C (AOAC No. 923.03, 1997). The protein content was determined with the Kjeldahl method with a conversion factor of 6.25 (AOAC No. 960.52, 1997). The lipid content was analyzed gravimetrically following the procedures in Bligh and Dyer (1959). Available carbohydrate was estimated by the difference between the whole mass and the sum of protein, fat, ash and moisture. The pH was measured using an EXTECH Instruments microcomputer pH-vision GEHACA®, model PG1800. The level of titratable acidity is expressed as malic acid (AOAC, 1997). Dietary fiber was measured using AOAC Method 985.29 (AOAC, 1997), which was performed with a Total Dietary Fiber Assay Kit purchased from Sigma-Aldrich, USA. The specific volume (mL/g) and the specific density (g/mL) were determined by the displacement of hexane in a 100 mL graduated cylinder. The water absorption index (WAI) and water solubility index (WSI) were determined with procedures used by Anderson, Conway, Pfeifer, and Griffin (1969). Color was determined by means of a colorimeter Color Reader CR-10 (Konica Minolta®), by reflectance, determining the components L^* to represent luminosity (0 = black; 100 = white), a (+a = redness; −a = greenness), and b (+b = yellowness; −b = blueness), according to the CIE-L*a*b* system. The chrome (C*) and hue angle (h*) values were calculated as described by Minolta (1994). The chrome value was calculated as shown in Eq. (1), and the saturation angle as shown in Eq. (2).

$$\text{Chrome}(C^*) = \left[(a^*)^2 + (b^*)^2\right]^{1/2} \quad (1)$$

$$\text{Hue angle}\ (h^*) = \tan^{-1}(b^*/a^*) \quad (2)$$

2.4. Analysis of triacylglycerol (TAG) by mass spectrometry — MALDI Q-TOF MS

Analysis of triacylglycerol was performed once the dehydration process may lead to lipidic alterations through oxidative damage, modification of the fatty acid profile as well as the characteristics of the lipidic fraction compared to the non-processed product (Nawar, 1993).

Marolo pulp oil was extracted using only *n*-hexane. For that purpose, 100 mg of the pulp was weighed in a tube, and 1 ml of *n*-hexane was added. The mixture was then homogenized by vortexing for 2 min. Afterwards, the tubes were centrifuged for 1 min, and the samples were analyzed by MALDI Q-TOF MS. For this task, 2 μL of the *n*-hexane phase was placed on the MALDI plate for the identification of triacylglycerols and kept at room temperature until the solvent was completely evaporated. MALDI matrix (1 μL) was added to the sample, and the sample was dried at room temperature. The matrix was prepared from 1% (m v^{-1}) 2,5-dihydroxybenzoic acid dissolved in 1000 μL methanol.

MALDI Q-TOF mass spectra were acquired in a MALDI Q-TOF Premier mass spectrometer (Waters — Micromass, Manchester, UK). The mass spectra were obtained in the positive ion mode (LDI+) with a fixed nitrogen ion source using the following parameters: mass range from 700.0 to 1000.0 Da, mass threshold of 200.0 Da, a scan time of 2 s, a resolution of 10,000 in "V" mode, a trigger threshold of 700 mV, a signal sensitivity of 80 mV and a microchannel-plate photomultiplier set to 2100 V. Each spectrum was collected over a 1-s scan, and the spectra were accumulated for 1 min. The instrument was controlled by the MassLynx 4.1v software (Waters — Micromass, Manchester, UK). All data obtained from MALDI Q-TOF MS were analyzed using the same software.